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Distribution of Chironomidae larvae in an Amazonian flood-plain lake impacted by bauxite tailings (Brazil)

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Abstract

We evaluated the distribution of Chironomidae larvae (Diptera: Insecta) during four periods of the flood pulse, and the possibility of using them as bioindicators of ecological conditions in an Amazonian lake impacted by bauxite tailings. The taxonomic composition was related to the presence of bauxite tailings comparing the natural area with the transition and impacted areas of Batata lake. Sediment samples (n = 5) were collected with a 50 cm^2 area corer sampler at each sampling station, during the four periods of water level fluctuation (filling, flood, drawdown, dry), from 1994 to 1996. Chironomidae larvae were identified under a microscope, using a 10 % lactophenol solution. Natural, transition and impacted areas were distinct when the physical and chemical parameters of the water column and sediment were compared. The functional feeding groups found were: 1 - predators, which swallow their prey in pieces or entirely (*Ablabesmyia, Coelotanypus, Djalmabatista pulcher, D.* sp. 1, *Labrundinia, Tanypus*, and *Cryptochironomus*); 2 - collectors, typical taxa of depositional areas in lentic ecosystems (*Chironomus, Cladopelma, Goeldichironomus, Fissimentum* and *Tanytarsini* genera varia); 3 - phytophylous fauna, typically associated with aquatic macrophytes (*Beardius, Harnischia* and *Polypedilum fallax*); 4 - adapted to water level fluctuations (*Fissimentum*); 5 - detritivorous, adapted to high organic matter content (*Chironomus* and *Polypedilum* sp. 1). The low number of taxa and density of chironomids in the impacted area corroborated to the role of these organisms as bioindicators of anthropic influence in freshwater ecosystems.
Keywords: **Chironomidae, Amazonia, biodiversity, bauxite mining, environmental impact.**

Resumo

Este estudo avaliou a distribuição das larvas de Chironomidae (Diptera: Insecta) durante os períodos de pulso hidrológico e a possibilidade de utilização destes organismos como bioindicadores das condições ecológicas em um lago amazônico impactado por rejeito de bauxita. Foi estudada a composição taxonômica em função da presença do rejeito de bauxita comparando-se a área natural com as áreas de transição e impactada. As amostras de sedimento (n=5) foram coletadas com um coletor tipo "corer" com área de 50 cm^2 em cada estação de coleta, durante os quatro períodos principais do ciclo hidrológico (enchente, águas altas, vazante e águas baixas) entre 1994 e 1996. As larvas de Chironomidae foram identificadas em microscópio, utilizando solução de lactofenol 10 %. As reas natural, transição e impactada foram

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diferentes quando analisados os parâmetros físicos e químicos de coluna d'água e sedimento. Os grupos tróficos funcionais encontrados foram: 1 - predadores, que engolem suas presas inteiras ou aos pedaços (*Ablabesmyia*, *Coelotanypus*, *Djalmabatista pulcher*, *D.* sp. 1, *Labrundinia*, *Tanypus*, e *Cryptochironomus*); 2 - coletores, típicos de áreas deposicionais em ecossistemas lênticos (*Chironomus* e *Tanytarsini genera varia*); 3 - fauna fitófaga, tipicamente associada a plantas aquáticas (*Goeldichironomus*, *Harnischia* e *Polypedilum fallax*); 4 - adaptados a flutuações de nível d'água (*Fissimentum*); 5 - detritívoros, adaptados a altas concentrações de matéria orgânica (*Chironomus* e *Polypedilum* sp. 1). O reduzido número de taxa e baixa densidade de larvas de Chironomidae na área impactada corrobora o papel destes organismos como bioindicadores de influência antrópica em ecossistemas lacustres.

Introduction

Since the beginning of the Limnology science, use has been made of the ecological studies of chironomidae larvae, focusing on their use as bioindicators (THIENEMANN 1921; LUNDBECK 1926, 1936; BRUNDIN 1949, 1956). These authors worked out a proposal for a lake typology using chironomids. More recently, other researchers have been using chironomids as a tool for environmental impact assessment (ROSENBERG & RESH 1993; ROSENBERG et al. 1986), toxicity tests (BUIKEMA & VOSHELL 1993), and aquatic ecosystem health evaluation (MOULTON 1998; BARBOSA et al. 2000; GALDEAN et al. 2000; CALLISTO et al. 2000b).

The evaluation of chironomid species diversity in the Neotropics has been accomplished in uncertain way, considering the great number of new species not yet described. Besides, the reduced number of taxonomic specialists still hinder the processing and identification of the collected biological material. Brazil, known as the megadiversity country (BARBOSA 1994; MYERS et al. 2000), possesses many areas where the taxonomic knowledge is still incipient, such as Pantanal, some altitudinal areas in the southeast and, specially, the Amazonia.

Chironomidae larvae are able to adapt to a wide variety of environmental conditions, such as extreme temperature, oxygen, and pH conditions. Besides that, morfophysiological and behavioural adaptations enable them to occupy almost all kinds of freshwater ecosystems (ARMITAGE et al. 1995; CHALONER & WOTTON 1996).

Batata lake (Porto Trombetas, Pará) has been intensively studied for more than one decade. Studies have been concentrated on basic limnological characteristics, including nutrient cycling, primary production, organic matter decomposition, and metabolism (ESTEVES et al. 1990; ROLAND & ESTEVES 1993, 1998; FERRÃO-FILHO & ESTEVES 1994; PANOSSO et al. 1995; ROLAND et al. 1997; ESTEVES et al. 1994). Aquatic communities have been studied in their different levels, considering phytoplankton (HUSZAR & REYNOLDS 1997; MELO & HUSZAR 2000), bacterioplankton (ANÉSIO et al. 1997), zooplankton (BOZELLI 1992, 1998), ictiofauna (REIS 1997), aquatic macrophytes (ENRICH-PRAST & ESTEVES 1996, 1998; ENRICH-PRAST et al. 1999), flooded vegetation (Igapó) (BARBIERI 1995), and benthic macroinvertebrates (CALLISTO & ESTEVES 1996a, b; FONSECA et al. 1998; FONSECA & ESTEVES 1999a, b). These studies have been using an holistic approach, considering the Trombetas river watershed, and more precisely, the stretch under bauxite mining influence as the major study area.

The goal of this study was to assess the distribution and taxonomic composition of chironomidae larvae and their possible use as bioindicators of ecological conditions in an Amazonian lake impacted by bauxite tailings.

Study area

Batata lake is situated between 1°25'-1°35'S and 56°15'-56°25'W, near Porto Trombetas, in Oriximiná municipality, Pará State, Brazil (Fig. 1). The lake is situated on the right bank of Trombetas River and has an area of approximately 2,100 ha. Batata lake shows high water level fluctuation related to Trombetas River flood pulse, when the transport of allochthonous organic matter into the lake is observed (ESTEVES et al. 1990). Due to the flood pulse in Batata lake (minimum values of 0.3 to 3.5m and maximum values of 5.5 to 9.0 m), there is high variation in its area, from approximately 18 km^2 (in flood period) to 30 km^2 (in dry period) (PANOSSO et al. 1995). Another organic matter source comprises the extensive banks of *Oryza glumaepatula* (Poaceae), the major aquatic macrophyte species that grows in Batata lake littoral zone. During flood periods this macrophyte contributes with organic material inputs to the lake. Mortality of most of this aquatic macrophyte occurs after the fruiting period (ENRICH-PRAST & ESTEVES 1998). Batata lake has clear waters (according to SIOLI, 1950), with pH varying from slightly acid up to basic (between 5.4 and 6.9) and electric conductivity around 12.0 µS/cm, common values to most of the clear water lakes in the area (SIOLI 1984; ESTEVES et al. 1994). During ten years (1979-1989), the lake received bauxite tailings through the water used in the bauxite washing process, which was pumped into the upper part of Batata lake in volumes ca. 18 million m^3 annually (LAPA & CARDOSO 1988).

Material and methods

The sediment samples were obtained with a 50 cm^2 area corer sampler, to a total of 5 samples at each of the 3 sampling stations (natural, transition, and impacted), during the four flood pulse phases (filling, flood, drawdown, and dry) of 1994, 1995, and 1996.

Water column temperature was measured with a FAC 400 digital thermometer. Digital equipment was used for pH and electric conductivity analysis (DIGIMED model DMPH-P and METROHM, respectively). Total alkalinity was measured by titration according to the GRAN method (modified by CARMOUZE 1994). The turbidity values were measured with a turbidimeter (LAMOTTE/2008), and suspended material by gravimetry, following filtration in GF/C filters. Dissolved oxygen content was measured through the WINKLER method (modified by GOLTERMAM et al. 1978). Chlorophyll-a concentrations were determined following NUSCHE & PALME (1975). In the sediment, organic matter concentrations (JACKSON 1962), available phosphorus (MORENO 1987), and total nitrogen (BEZERRA 1987) were measured.

Sediment samples were washed through 1,00 and 0,50 mm sieves. Density values (ind/m^2) were calculated by the sum of the 5 samples taken. Chironomidae larvae were identified under a microscope (400 x magnification), using a 10 % lactophenol solution. The identified organisms were deposited in the Benthic Macroinvertebrates Collection at the Institute of Biological Sciences, Federal University of Minas Gerais, as described by CALLISTO et al. (1998).

A Principal Component Analysis (PCA) using r PERSON was performed with the abiotic data, using the software StatSoft, Statistica 1991.

The evaluation of functional feeding groups was performed based on laboratory analysis, field observations, and the available literature (EPLER 1995; CRANSTON 1996) and ecological strategies were identified considering: 1 - predators, which swallow their prey in pieces or entirely (*Ablabesmyia, Coelotanypus, Djalmabatista pulcher, D.* sp.1, *Labrundinia, Tanypus*, and *Cryptochironomus*); 2 - collectors, which are typical of depositional areas in lentic ecosystems (*Chironomus, Cladopelma, Goeldichironomus, Fissimentum* and *Tanytarsini genera varia*); 3 - phytophylous fauna, typically associated with aquatic macrophytes (*Beardius, Harnischia* and *Polypedilum fallax*); 4 - adapted to water level fluctuations (*Fissimentum*); 5 - detritivorous, adapted to high organic matter content (*Chironomus* and *Polypedilum* sp. 1).

Results and discussion

Physical and chemical characteristics of the water column and sediment

The impacted sampling station was significantly different from the others, considering its physical and chemical characteristics, especially concerning turbidity values, suspended material and water transparency (see FONSECA & ESTEVES 1999a). On the other hand, the natural sampling station is characterized by higher values of organic matter, total nitrogen, and available phosphorus in the sediment. The transition sampling station is characterized by intermediate values when compared to those obtained in the two other areas.

The spatial distribution of the limnological parameters on the first two axes corresponded to 50,6 % of data variance (Fig. 2). Four groups of variables were identified and distributed among the four quadrants formed by both axes. The first group was composed of the variables "Secchi disk" and "water column depth", which contributed to the positive variation on the first axis. The second group is composed of the following variables: suspended material, chlorophyll-a, total alkalinity, temperature, and dissolved oxygen; which contributes to the negative variation on the first axis. The sediment variables (organic matter content, total nitrogen and available phosphorus) formed a third group plotted in the first quadrant, which accounted for the positive variation on the second axis, and which had, as a negative variable, the turbidity. The variables "pH" and "electric conductivity" were plotted close to the intersection of the two axes, representing similar values of these two variables for both sampling stations and sampling periods.

The sampling stations were separated according to the presence of bauxite tailings, while the samples from the impacted area were plotted on the second and third quadrants. These points were negatively correlated to the organic matter content, total nitrogen and available phosphorus in the sediment, reflecting the low values of these parameters in the impacted zone. The transition and natural areas, with high concentration of total nitrogen and available phosphorus in the sediment were plotted positively. However, the transition area showed a tendency to be plotted between the natural and impacted areas, thus reflecting intermediate characteristics.

The sampling point distribution was influenced by the flood pulse, and, in this case, the same distribution pattern was observed in the three sampling areas. Samples collected during filling and flood periods were plotted positively relating to the variables "Secchi disk" and "depth". On the other hand, samples collected during the drawdown and the dry periods were correlated with suspended material, chlorophyll "a", temperature and dissolved oxygen.

The abiotic variables on the water column accounted for the sampling period differentiation during the flood pulse, while the sediment variables in Batata lake contributed to the sampling areas distinction, separating the impacted area from the others. These results corroborate what was previously found in Batata lake analysed data from 1989 up to 1993 (CALLISTO & ESTEVES 1995; FONSECA & ESTEVES 1999a).

Distribution and taxonomic composition of chironomidae larvae

The mean density of Chironomidae larvae in the natural area (407.27±326.35 ind/m^2) was significantly higher (KRUSKAL-WALLIS, $p < 0.05$) than the mean density observed in the impacted area (123.63±158.45 ind/m^2). The mean density found in the transi-

tion area (321.45±291.24 ind/m^2) was intermediate to the values shown in the natural and impacted areas, which is not significantly different (KRUSKAL-WALLIS, $p > 0.05$). Chironomid larvae density and taxonomic composition data in Batata lake is shown in Tables 1, 2 and 3.

The highest number of taxa, was found in the natural area (3.9±2.2), followed by the transition area (3.6±2.8) and the impacted area (1.7±1.5). However, these results were not significantly different among the sampling stations (KRUSKAL-WALLIS, $p > 0.07$). Besides that, it must be mentioned that there is a lack of regularity in the taxonomic composition changes during the flood pulse in Batata lake when comparing the studied years.

The tanypods *Coelotanypus, Labrundinia* and *Tanypus* prevailed in the natural area. Densities were high, among Chironominae, *Chironomus* and *Cladopelma* as they were the most abundant in the dry periods of 1995 and 1996, respectively. *Fissimentum* was numerically important during the filling phase of the lake in 1994.

A similar taxonomic composition was observed in the transition area, when compared to the natural area. *Coelotanypus* and *Labrundinia* were dominant in most of the sampling sites. *Coelotanypus* was the only taxa found in the 3 sampling periods. *Cladopelma* was dominant in the dry period of 1995 while *Fissimentum* was dominant in the drawdown period of 1994 and filling of 1995.

Lower taxa and density values of organisms were found in the impacted area, with *Coelotanypus* prevalence in the flood and drawdown periods of 1995 and the dry period of 1996.

Djalmabatista pulcher and *Polypedilum fallax* were found only in 1996 (drawdown and dry periods) in low densities, only in the impacted area, and were not found in the natural and transition areas. *Coelotanypus* and *Fissimentum* were the most common taxa, with higher densities, and more frequent in the natural and transition areas, while in the impacted area they were found in smaller density and frequency.

The samples collected in the three sampling stations during the flood period of 1994 were used to assess the benthic organisms biomass in FONSECA et al. (1998). Otherwise, in the dry period of 1995 and drawdown of 1996, chironomid larvae were not found in the impacted area.

The classification in functional feeding groups and the ecological strategies indicated high abundance of predators, followed by detritivorous, filtering-collectors, and herbivorous (Fig. 3). In the natural area, predator dominance was observed along the studied period. On the other hand, during the filling period of 1996, herbivorous dominance was observed, while, during the dry period of 1996, filtering-collectors were dominant. In the transition area, detritivores prevailed in the drawdown period of 1994, except in the dry period of 1995 and 1996. In the impacted area, during the filling period of 1996, only detritivores were found. The flood pulse and the littoral moving of organic matter provide changes in the kind of resource available to the macroinvertebrates. The dominance of a functional feeding group seems to be closely related to the four hydrologic periods of the flood pulse, and, more specifically, with the substrate type (NESSIMIAN et al. 1998).

The Batata lake sediment is composed of fine particles (silts and clays) (CALLISTO & ESTEVES 1996a). ANÈSIO et al. (1997) evidenced strong relationship between the bacterioplankton and the suspended clay particles, especially in the impacted area. With clay particle sedimentation, the sediment surface probably has its energy content

enriched by bacterial biomass or by a possible high abundance of meiobenthos (e.g., microcrustaceans and others) which have been described as preys of tanypods. Detritivorous larvae would use this available trophic resource (WARD 1992), and, in turn, could be energy source for predators capable of working in chironomid diversity control (CALLISTO et al. 2000a).

The presence of *Fissimentum* may be related to the water level fluctuation. Larvae of this taxon can support drying periods due to water level decrease, continuing to exist in resistence forms (CRANSTON & NOLTE 1996). *Fissimentum* densities in the sediment of Batata lake suggest that they are more abundant in natural and transition areas, compared with the impacted area. As pointed out by CRANSTON & NOLTE (1996), in these areas, the larvae live in soft and muddy sediments. Conversely, the presence of this genus in the impacted area, was probably due to the fine granulometric composition and low nutrient contents in the sediment. The same pattern of spatial distribution was found in other freshwater systems in the same watershed.

Chironomus and *Polypedilum* are commonly found in fine sediments with high organic matter content of natural (CALLISTO et al. 1999) or anthropogenic origin (MARQUES et al. 1999). These taxa are typical of lentic or lotic depositional habitats, diggers (with tubes), collectors, and few are filter-feeders, scrapers, herbivorous and miners.

The ecological strategies for obtaining food are diversified among chironomid larvae in Batata lake. Most of the Tanypodinae genera are sprawlers-swimmers, very active predators, engulfers and piercers, not tube builders (WIEDERHOLM 1983). *Coelotanypus* larvae are burrowers-predators, engulfers of Oligochaeta, Cladocera and other chironomids. *Djalmabatista* spp. are usually sprawlers and predators (engulfers). They mainly inhabit lotic environments. *Ablabesmyia* and *Labrundinia* larvae inhabit areas with lentic or lotic-erosional and depositional characteristics, consisting of sprawlers, predators (engulfers and piercers of Rotifera, microcrustacea and other chironomids or collectors-gatherers (early instars).

The results obtained in this study represent a contribution to the knowledge of the distribution and taxonomic composition of chironomid larvae in Batata lake, during the flood pulse of Trombetas river. In the future, taxonomic studies must be deepened, focusing on identifying the Chironomidae species present in Batata lake. Probably, the deposition of bauxite tailings over the original natural sediment of Batata lake can be responsible for some effects at a population level (e.g., mortality rates, morfological deformities). Besides that, the accomplishment of ecophysiologic experiments with the larvae will also be necessary to evaluate the ecological consequences of the siltation by clay particles on the lake's natural sediment.

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Table 1: Density (ind./m^2) and taxonomic composition of chironomid larvae in the natural area of Batata lake. (*) biological data used in FONSECA et al. (1998); (1) filling 1994, (2) flood 1994, (3) drawdown 1994, (4) dry 1994, (5) filling 1995, (6) flood 1995, (7) drawdown 1995, (8) dry 1995, (9) filling 1996, (10) flood 1995, (11) drawdown 1995, (12) dry 1995.

Natural Area (* biological data according to FONSECA et al. 1998)

		1994				1995				1996		
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Tanypodinae												
Ablabesmyia	-	*	-	40	-	-	-	-	-	-	-	-
Coelotanypus	120	*	40	80	-	280	240	120	40	-	120	160
Djalmabatista	120	*	-	40	-	40	-	40	-	-	-	-
Labrundinia	240	*	-	80	200	-	-	80	-	-	-	80
Tanypus	-	*	-	-	160	-	-	-	-	-	-	-
Tanypodinae unidentified	-	*	-	-	-	-	80	-	40	-	-	-
Chironominae												
Beardius	-	*	-	40	-	-	-	-	-	-	-	-
Chironomus	-	*	-	40	-	-	80	40	-	-	-	760
Cladopelma	40	*	-	-	-	-	80	160	-	-	-	40
Fissimentum	200	*	-	40	40	-	-	-	-	-	40	80
Goeldichironomus	-	-	-	-	-	-	-	-	40	-	-	-
Harnischia	-	*	-	-	-	-	-	-	120	-	-	40
Polypedilum	-	*	-	-	-	-	-	40	-	-	-	-
Pupae unidentified	-	*	-	-	-	40	-	40	40	-	-	-
Total density	720	305	40	360	400	360	480	520	280	-	160	1160
Number of taxa	5	*	1	7	3	3	4	7	5	-	2	6

Table 2: Density (ind./m^2) and taxonomic composition of chironomid larvae in the transition area of Batata lake. (*) biological data used in FONSECA et al. (1998); (1) filling 1994, (2) flood 1994, (3) drawdown 1994, (4) dry 1994, (5) filling 1995, (6) flood 1995, (7) drawdown 1995, (8) dry 1995, (9) filling 1996, (10) flood 1995, (11) drawdown 1995, (12) dry 1995.

Transition Area

		1994				**1995**				**1996**		
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Tanypodinae												
Ablabesmyia	-	*	-	40	-	-	-	-	-	-	-	-
Coelotanypus	40	*	40	80	120	120	120	160	-	280	80	120
Djalmabatista	-	*	-	40	80	-	-	-	-	-	-	-
Labrundinia	40	*	-	80	-	-	-	40	-	-	-	-
Tanypus	-	*	-	-	80	-	-	-	-	-	-	-
Tanypodinae unidentified	-	*	-	-	40	-	-	-	-	-	-	-
Chironominae												
Beardius	-	*	-	40	-	-	-	-	-	-	-	-
Chironomus	-	*	-	40	40	-	-	-	40	40	-	40
Cladopelma	-	*	-	-	-	-	-	520	-	-	-	-
Cryptochironomus	-	*	-	-	-	-	-	-	-	40	-	-
Fissimentum	-	*	120	40	120	-	-	80	240	-	-	40
Goeldichironomus	-	*	-	-	-	-	-	40	-	-	-	-
Harnischia	-	*	-	-	80	-	-	-	-	-	-	-
Polypedilum	-	*	-	-	-	-	40	-	-	-	-	-
Tanytarsini genera varia	-	*	-	-	80	-	-	40	-	-	-	-
Pupae unidentified	-	*	-	-	40	-	-	40	40	-	-	-
Total density	80	360	160	360	580	120	120	960	320	360	80	200
Number of taxa	2	*	2	7	9	1	1	8	3	3	1	3

Table 3: Density (ind./m^2) and taxonomic composition of chironomid larvae in the impacted area of Batata lake. (*) biological data used in FONSECA et al. (1998); (1) filling 1994, (2) flood 1994, (3) drawdown 1994, (4) dry 1994, (5) filling 1995, (6) flood 1995, (7) drawdown 1995, (8) dry 1995, (9) filling 1996, (10) flood 1995, (11) drawdown 1995, (12) dry 1995.

Impacted Area

		1994				**1995**				**1996**		
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Tanypodinae												
Ablabesmyia	-	*	-	-	-	-	-	-	-	40	-	-
Coelotanypus	-	*	40	-	-	240	200	-	-	-	-	-
Djalmabatista sp.1	-	*	-	40	-	-	-	-	-	-	-	-
Djalmabatista pulcher	-	-	-	-	-	-	-	-	-	-	-	120
Labrundinia	-	*	-	40	-	-	40	-	-	-	-	-
Tanypus	-	*	-	-	-	-	80	-	-	-	-	-
Chironominae												
Chironomus	40	*	-	-	-	-	80	-	-	-	-	-
Cladopelma	-	*	-	-	-	-	120	-	-	40	-	-
Fissimentum	-	*	-	-	-	-	-	-	40	-	-	40
Polypedilum spp.	-	*	-	-	-	40	-	-	-	-	-	-
Polypedilum fallax	-	-	-	-	-	-	-	-	-	40	-	-
Tanytarsini												
genera varia	40	*	-	-	-	-	-	-	-	-	-	40
Total density	80	170	40	80	-	280	320	-	40	120	-	200
Number of taxa	2	*	1	2	-	2	5	-	1	3	-	3

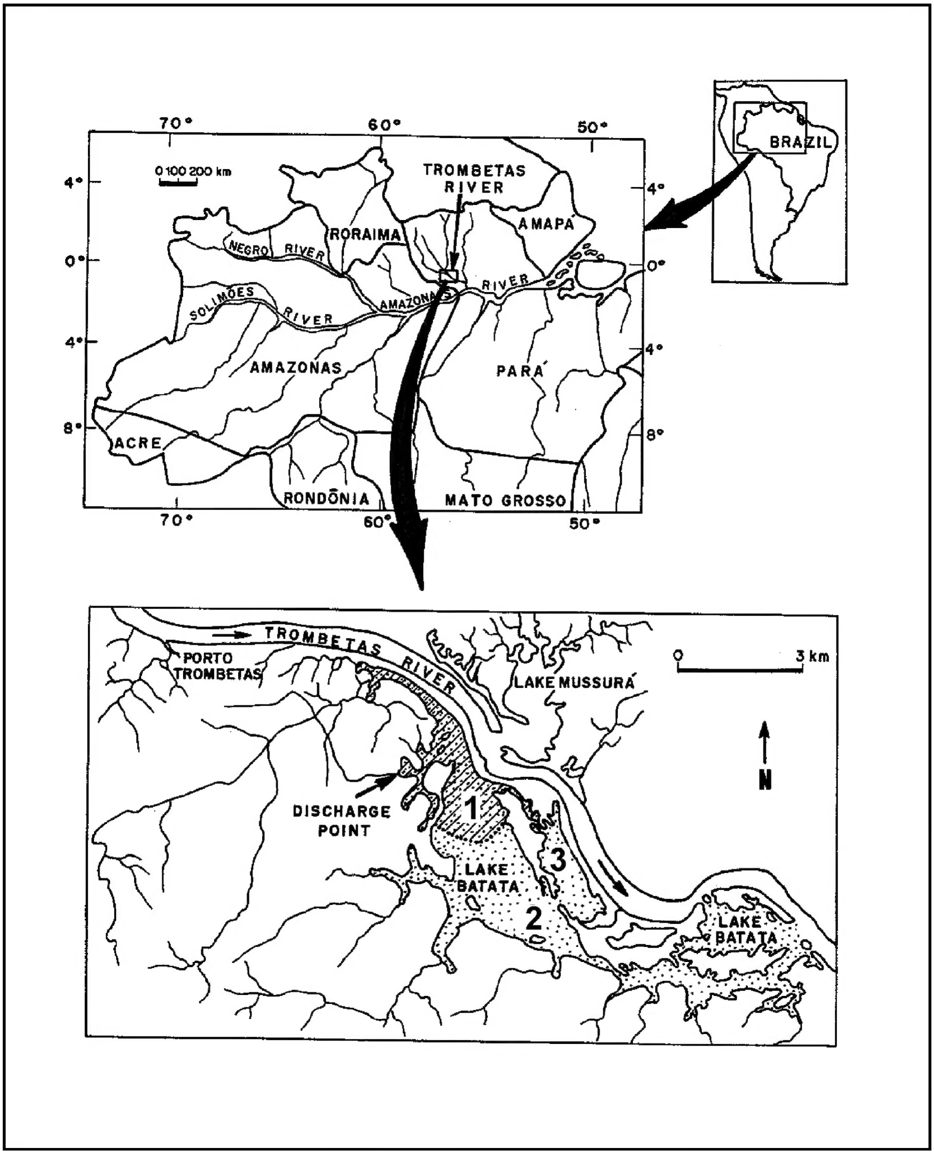

Fig. 1:
Map showing location of study area and sampling stations.

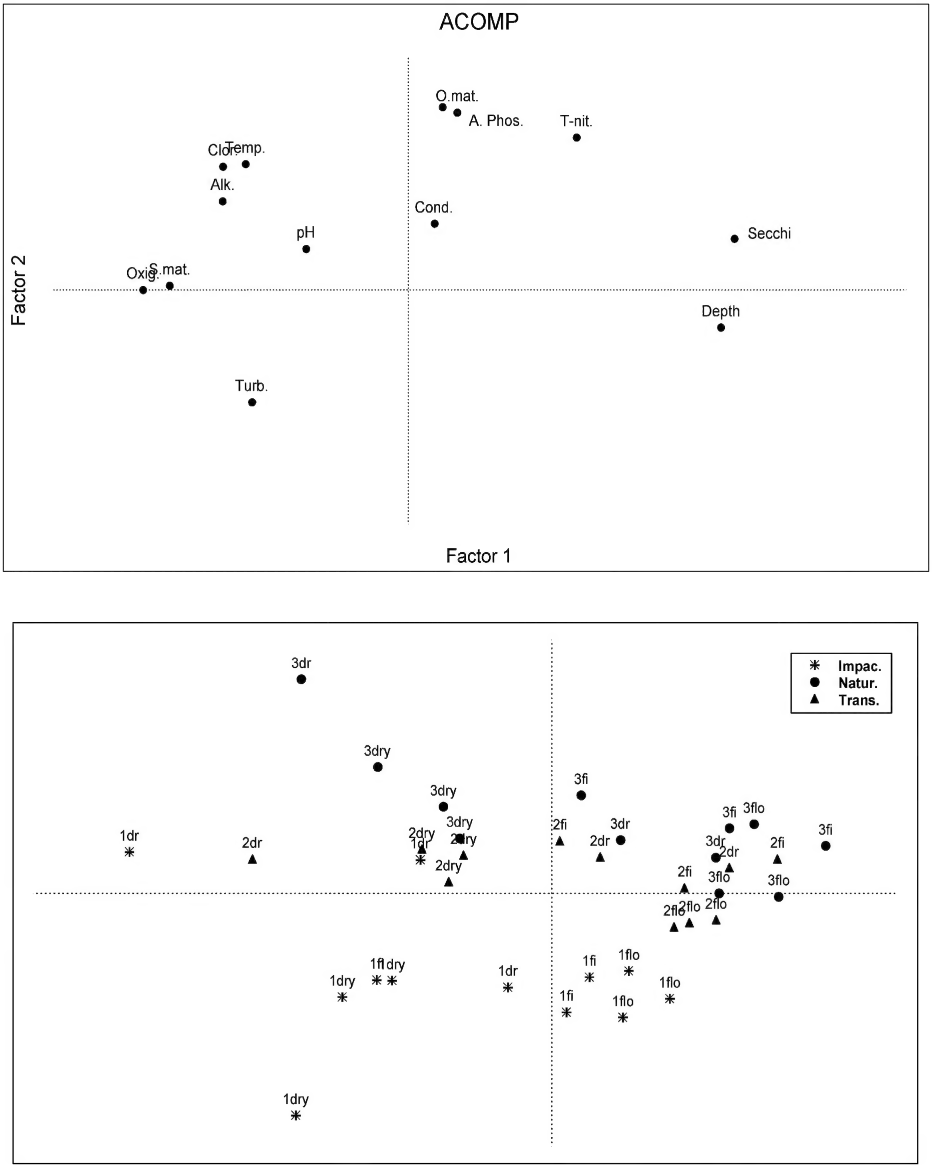

Fig. 2:
Principal Component Analysis, using pH, electrical conductivity (Cond.), total alkalinity (Alkal.), temperature (Temp.), turbidity (Turb.), suspended material (S. Mat.), dissolved oxygen (Oxyg.), chlorophyll "a" (Clor.), depth (Depth), Secchi disk (Secchi) in the water collumn, and organic matter (O. Matt.), available phosphorus (A. Phos.) and total nitrogen (t-Nitr.) in the sediment, calculated for impacted (1), transition (2) and natural (3) areas, during the four flood pulse periods: filling (fi), flood (flo), drawdown (dr) and dry (dry) from 1994 up to 1996.

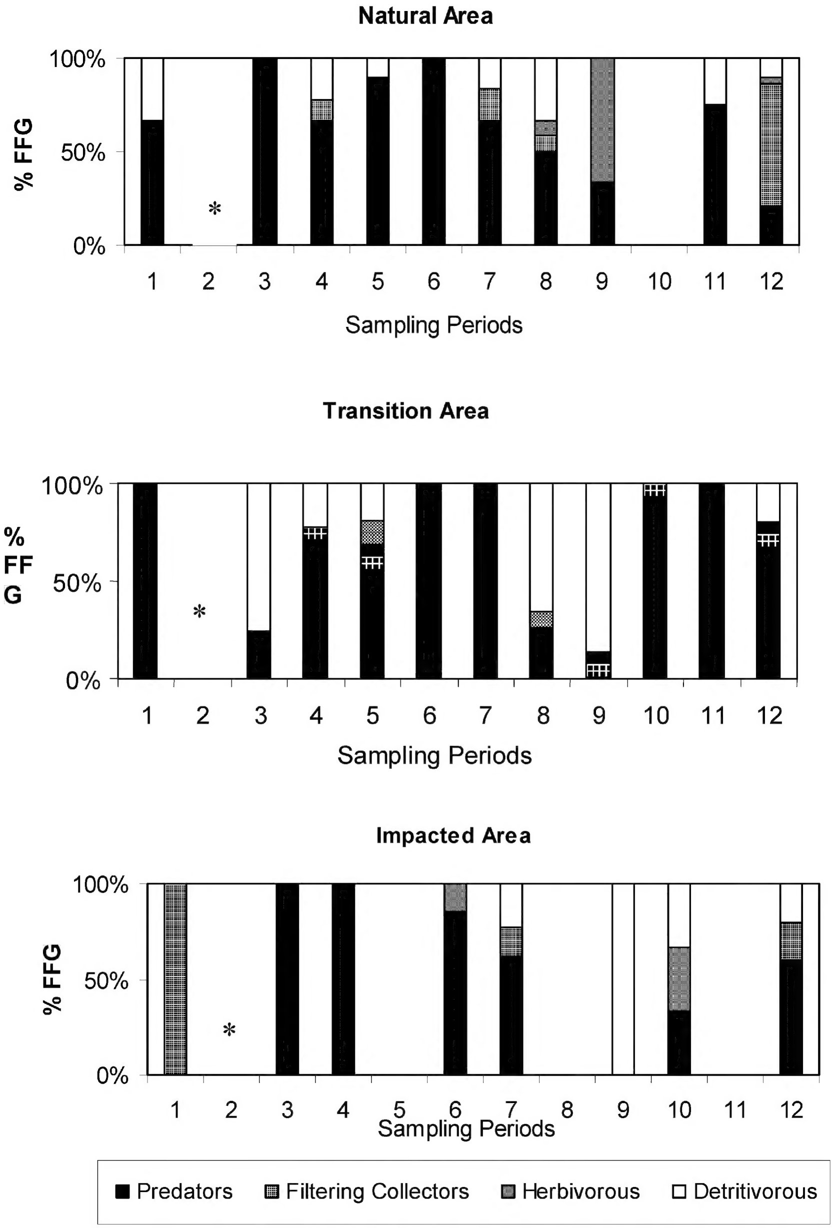

Fig. 3:
Chironomid larvae classification in functional feeding groups in the 3 areas of Batata lake, in the four flood pulse phases from 1994 up to 1996. (1) filling 1994, (2) flood 1994, (3) drawdown 1994, (4) dry 1994, (5) filling 1995, (6) flood 1995, (7) drawdown 1995, (8) dry 1995, (9) filling 1996, (10) flood 1995, (11) drawdown 1995, (12) dry 1995.